



Georgia Basin-Puget Sound Ecosystem Indicators Report
Technical Backgrounders

Air Quality • PM10

Spring 2002

**Transboundary Georgia Basin-Puget Sound
Working Group on Environmental Indicators**

Georgia Basin Ecosystem Initiative, Environment Canada
BC Ministry of Water, Land and Air Protection
Puget Sound Water Quality Action Team
Washington State Department of Ecology
US Environmental Protection Agency

Air Quality from PM₁₀ in the Georgia Basin

Primary Indicator: *Percentage of communities exposed to health risks from inhalable particulates where PM₁₀ is greater than 25 µg/m³ at least 5% of the time.*

Quality Impacts in the Georgia Basin From Inhalable Particulates

Selection of the Indicator

Suspended particulate matter is composed of tiny, airborne solid or liquid particles other than pure water. Particles with aerodynamic diameters of 10 micrometers (µm) or less are referred to as *inhalable particulates* or PM₁₀. Particles larger than 10 µm settle to the ground relatively quickly and are of little concern from a health perspective because they tend to collect in the throat and nose, and are eliminated from the body by sneezing, coughing and nose blowing, or through the digestive system. PM₁₀ is generally considered to be inhalable, bypassing the body's outer defense mechanisms and penetrating into the lungs, posing a threat to human health.

This indicator considers the percentage of communities in the Georgia Basin where air quality monitoring stations recorded PM₁₀ levels above 25 µg/m³ over a 24-hour averaging period for more than 5% of the time (see Table 1). The level of 25 µg/m³ is the level at which there is statistical evidence of health effects (CEPA/FPAC Working Group on Air Quality Objectives and Guidelines 1998). Current health studies, however, have not been able to determine a threshold concentration below which there are no effects (Schwartz et al. 1996). Exposure to PM₁₀ concentrations of greater than 25 µg/m³ for at least 5% of the time corresponds to an equivalent of 18 days/year.

The British Columbia Provincial Health Officer has identified inhalable airborne particulates as an important outdoor contaminant in British Columbia (Provincial Health Officer, 1998). It is not yet possible to conclude whether it is particle size, mass or composition that is responsible for the observed health impacts. It is known that the smaller the particle size, the deeper it can penetrate into the lungs. Once in the lungs, particles affect pulmonary function on either a temporary or permanent basis. PM₁₀ may contribute to the development of chronic bronchitis and may be a predisposing factor to acute bacterial and viral bronchitis. It may also aggravate bronchial asthma, the late stages of chronic bronchitis, pulmonary emphysema, existing cardiovascular disease, and several other lung-related impairments. Senior citizens and people with existing lung or heart problems are most at risk from PM₁₀, but healthy adults and children can also be affected. In addition to these health impacts, PM₁₀ also impacts visibility.

Air Quality in the Greater Vancouver Regional District is reported as GOOD, FAIR, POOR or VERY POOR in the Air Quality Index. A FAIR PM₁₀ corresponds to a concentration of more than 25 µg/m³ but not more than 50 µg/m³. A POOR rating corresponds to a concentration above 50 µg/m³ but not more than 100 µg/m³. A VERY POOR rating corresponds to a concentration greater than 100 µg/m³.

Data and Sources

Table 1: Percentage of Time PM10 Concentrations Are Greater Than 25 ug/m3 in Georgia Basin Communities

Site Name	Sampler type*	% of time PM 10>25 ug/m3					
		1994	1995	1996	1997	1998	1999
Abbotsford	s	17.0	d	n	n	n	n
Abbotsford Library	t	d	d	d	12.6	9.4	3.6
Burnaby South	t	d	11.8	7.9	6.8	8.0	4.1
Campbell River Tyee Split	t	n	n	n	d	8.8	2.5
Chilliwack Airport	t	n	d	10.3	6.3	10.4	d
Duncan Deykin Avenue	t	n	n	n	n	d	0.6
Hope Airport	t	n	n	d	3.0	4.7	0.6
Kitsilano	t	5.8	7.7	4.7	3.6	5.5	4.4
Langdale Elementary	t	n	n	0.0	0.5	d	d
Langley	t	4.5	d	4.4	1.8	d	3.3
Mission	s	29.4	32.1	13.6	8.5	11.7	20.3
North Delta	t	8.7	d	8.6	2.5	d	3.3
Pitt Meadows Airport	s	5.4	6.9	d	n	n	n
Powell River Cranberry Lake	t	n	n	7.6	4.7	4.2	0.3
Quadra Island Lighthouse	t	n	n	n	d	d	0.6
Richmond South	t	4.7	8.7	12.4	8.8	3.8	1.1
Rocky Point Park, Port Moody	t	14.3	15.6	8.6	6.7	8.8	4.2
Squamish	t	d	16.3	15.0	d	4.7	11.1
Surrey East	t	5.2	3.5	4.4	2.8	4.2	1.4
Victoria PAPS	s	d	5.4	d	d	n	n
Victoria Topaz	s	n	n	n	n	n	24.1
# of communities monitored		9	9	12	13	12	16
# communities>25, 5% of time		7	8	8	6	7	3
Percent of monitored communities with levels of 25ug/m3 more than 5% of the time		77.8	88.9	66.7	46.2	58.3	18.7

d = minimum data reporting criteria of 75% of sample days/month and at least 11 months/year were not met.
n = no samples taken. Notes: * s - represents non-continuous sampling; t - represents continuous sampling.
Source: BC Ministry Of Environment, Lands & Parks, 2000, Air Resources Branch.

Methodology and Reliability

This indicator shows the percentage of monitored communities where the concentration of PM₁₀ exceeded 25 µg/m³ and did so more than 5% of the time during the year. The British Columbia State of Environment Reporting Office chose the 5% criterion after consultation with experts in air resources. This criterion was selected to provide a robust year-to-year indicator of air quality.

Data from two types of sampling devices were used to determine the percentage of time PM₁₀ exceeded 25 µg/m³ in communities in the Georgia Basin.

Continuous measurements were obtained using a Tapered Element Oscillating Microbalance (TEOM®). Non-continuous measurements were obtained using either a Size-Selective Inlet (SSI) high-volume sampler, or a Partisol® sampler. Both the SSI and Partisol® samplers are typically operated over a 24-hour period once every six days. Where both continuous and non-continuous samplers were used in a community, the data from the continuous samplers were chosen because they offer the better temporal resolution and hence a better measure of exposure.

When comparing these two methods it is important to note that there are some differences in the way that the data are collected.

Non-continuous Samplers (SSI and Partisol Samplers)

The non-continuous samplers draw air through an inlet which separates particles 10 µm or smaller in diameter from those larger than 10 µm.¹ Particles are collected on a pre-weighed filter and sent to a laboratory for analysis. The weight of the particles divided by the volume of air filtered determines the concentration of PM₁₀ in the air.

Continuous Samplers (TEOM® samplers)

The continuous samplers (TEOM® samplers) utilize an inlet designed to exclude particles greater than 10 µm in diameter from the air sample stream. A filter sits at the end of a tapered tube that is maintained in a clamped-free mode (like a tine on a tuning fork). The air sample stream is drawn through the filter (where particles are deposited) and through the tapered tube to a flow controller. As the filter mass changes the oscillating frequency of the tube changes. PM₁₀ concentrations can be determined through the corresponding frequency change. To eliminate interference from particle-bound water, the air stream is heated to a temperature of 40°C², thereby driving off any free, non-bound water. In so doing, the TEOM® can also drive off semi-volatile compounds such as ammonium nitrate and certain hydrocarbons. This may result in a difference of as much as 30%³ between the two sampling methods. The exact amount

¹ Inlet design is based on a 50% cutpoint of 10 µm. The 50% cutpoint is the particle size for which the sampler collects 50% of the sample and rejects 50%. This means that particles above 10 µm are collected, but at progressively less efficiency.

² The TEOM® was originally designed to operate at a sampling temperature of 50°C. However, due to concerns over excessive volatilization of compounds such as ammonium nitrate and some organic compounds, the sampling temperature was reduced to 40°C in all BC instruments as of Jan. 1/98.

³ This value is based on studies done in the UK, which indicated that the TEOMs® underestimated the non-continuous samplers by 15-30%. As a result, the UK assumes an undercatch of 30% when comparing their data to that collected by other EU countries using non-continuous samplers.

depends on environmental conditions (e.g., temperature) as well as the composition of the particles.

Data Inclusion Criteria

Both sampling methodologies may underestimate the percentage of time that PM₁₀ poses a health risk, but for different reasons. The non-continuous samplers typically operate only once every six days, so they run the risk of missing some of the high PM₁₀ days. TEOM instruments operate continuously, but may volatilise a portion of the PM₁₀ due to its high sampling temperature.

Data from non-continuous PM₁₀ samplers were used only when TEOM data were not available for a community. Data reporting requirements included a minimum of 75% of possible samples per month and a minimum of 11 valid months per year. This translates to a minimum of 4 samples per month from the non-continuous monitoring sites (assuming sampling takes place every six days), and a minimum of 540 hours per month at the TEOM sites, although these amounts will vary with the number of days in the month.

References:

Air Resources Branch. 1995. *Fine Particulates, What They Are and How They Affect Us*. Ministry of Environment, Lands and Parks, Air Resources Branch.
<http://www.elp.gov.bc.ca/epd/epdpa/ar/particulates/fpwtatht.html>

Canadian Environmental Protection Act (CEPA)/Federal-Provincial Advisory Committee (FPAC) Working Group on Air Quality Objectives and Guidelines 1998. National Ambient Air Quality Objectives for Particulate Matter. Science Assessment Document.

Provincial Health Officer. 1998. *A Report on the Health of British Columbians: Provincial Health Officer's Annual Report 1998*. Ministry of Health and Ministry Responsible for Seniors.

Schwartz, J., Dockey, D.W. and Neas, L.M. (1996) Is daily mortality associated specifically with fine particles? *J. Air Waste Manage. Assoc.* 46: 927-939.

Secondary Measure:

Location of communities having health risks from PM₁₀.

Selection of Indicator

This indicator shows the percentage of time in 1999 that air quality monitoring stations in each community used in the primary indicator recorded levels above 25 µg/m³, the level at which health effects have been demonstrated.

Data and Source

Location of Sampling Station by Ecoprovince	Sample r type*	% of Time in 1999 > 25 µg/m ³
Georgia Depression		
Vancouver Kitsilano	t	4.4%
Burnaby South	t	4.1%
Richmond South	t	1.1%
Rocky Point Park, Port Moody	t	4.2%
Surrey East	t	1.4%
Abbotsford Library	t	3.6 %
Mission	s	20.3%
Campbell River Tyee Split	t	2.5%
Powell River Cranberry Lake	t	.3%
North Delta	t	3.3%
Langley	t	3.3%
Quadra Island Lighthouse	t	.6%
Victoria Topaz	s	24.1%
Duncan, Deykin Avenue	t	.6%
Coast and Mountains		
Hope Airport	t	.6%
Squamish	t	11.1%

Notes: * t - continuous sampler (TEOM); s - non-continuous sampler (SSI), samples once every six days. For a community to be included in this analysis data must have been collected for 75% of the hours in at least 11 months of that year.

Source: BC Ministry of Environment, Lands and Parks, 2000. Air Resources Branch.

Methodology and Reliability

There has been considerable debate in the scientific community as to the level at which health effects begin from inhalable particulate matter. Scientific studies have shown that health impacts are observed at even low concentrations, and that the effects increase as concentrations increase. The Federal-Provincial Working Group responsible for the PM Science Assessment Document recommended a reference level of 25 µg/m³ (24-h avg.), above which there is some certainty that health impacts are occurring. This level has been adopted for this indicator.

Each pie on the map depicts the percentage of time that inhalable particulate concentrations exceeded 25µg/m³ for that community. The communities presented on the map represent those where the minimum data inclusion requirements were met.

References:

Ministry of Health. 1994. *Particulate Matter Air Pollution: What you can't see may be very dangerous to your health!* British Columbia Ministry of Health and Ministry Responsible for Seniors, Health File #35 - Spring 1994.

<http://www.hlth.gov.bc.ca/hlthfile/hfile35.html>

Provincial Health Officer. 1994. *A Report on the Health of British Columbians: Provincial Health Officer's Annual Report 1994*. Ministry of Health and Ministry Responsible for Seniors.

Smog an Indicator of potential air quality health risk in the Lower Fraser Valley
http://www.ecoinfo.org/env_ind/region/smog/smog.htm

Vedal, S. 1995. *Health Effects of Inhalable Particulates: Implications for British Columbia*. Report prepared for the Air Resources Branch, British Columbia Ministry of Environment, Lands and Parks.

Supporting Information

Sources of PM₁₀ in the Lower Fraser Valley (LFV)

The LFV Airshed encompasses virtually the entire Greater Vancouver Regional District as well as the southwestern more populated portions of the Fraser Valley Regional District.

PM₁₀ originates from both anthropogenic (generated by human activity) and natural sources. In the table below, sources have been divided into four main categories: three are anthropogenic (point sources, area sources, and mobile sources) and one natural (marine aerosols). Only primary emissions of PM₁₀, (i.e. those directly emitted) are quantified. Secondary particulates formed by chemical reactions in the atmosphere from precursor pollutants such as NO_x (nitrogen oxides) and VOCs (volatile organic compounds) contribute significantly to ambient PM₁₀ levels. The emission inventory does not estimate quantities of secondary PM₁₀ but does report on the gaseous precursor pollutants. Automobiles are a large source of these precursors.

Data and Source

Sources of Primary Emissions of PM₁₀ in the Lower Fraser Valley (LFV)		
Sector	tonnes	%
POINT SOURCES	3,818	35.7%
Bulk Shipping Terminals	1,443	13.5%
Electric Power Generation	82	0.8%
Chemical Manufacturing	13	0.1%
Metal Foundries/Fabrication	153	1.4%
Non-Metallic Mineral	494	4.6%
Petroleum Refining	181	1.7%
Paper and Allied Products	41	0.4%
Wood Products	1,039	9.7%
Other Point Sources	579	3.5%
AREA SOURCES	3,889	36.3%
Agricultural	1,842	17.2%
Solvent Evaporation	0	0.0%
Fuel Marketing	0	0.0%
Space Heating	1,012	9.5%
Landfills	25	0.2%
Burning	451	4.2%
Other Area Sources	559	5.2%
MOBILE SOURCES	2,671	24.9%
Light-Duty Vehicles	376	3.5%
Heavy-Duty Vehicles	337	3.1%
Aircraft	79	0.7%
Railway	1,301	12.2%
Marine Vessels	250	2.3%
Other Off-Road	327	3.1%
TOTAL, Anthropogenic	10,378	96.9%
NATURAL SOURCES*		
Marine Aerosol	330	3.1%
TOTAL	10,708	100%

Source: 1998 Emissions Inventory for the Lower Fraser Valley Airshed.

*The 1995 B.C. Emission Inventory Summary also lists wildfires as well as marine aerosol as the natural sources of PM₁₀ in BC and in the Lower Fraser Valley in 1995. Wildfires are a significant natural source of PM₁₀ in parts of BC. However, wildfires were not included in the 1998 Emissions Inventory for the Lower Fraser Valley Airshed.

Methodology and Reliability

The following includes a definition of each source category (Point Sources, Area Sources, Mobile Sources and Natural Sources) and a description of the methods used to estimate 1998 emissions for that category.

Point Sources

Point sources include all stationary facilities that operate under permits issued either under the provincial Waste Management Act or under the Greater Vancouver Regional District Air Quality Management Bylaw (No. 725). There are a number of other sources outside the GVRD but within the Lower Fraser Valley that operate under Ministry permit, approval or regulation.

The 1998 point source inventory categories are:

- bulk shipping terminals
- chemical manufacturing
- electric power generation
- metal foundries and metal fabrication
- municipal solid waste (MSW) incineration
- non-metallic mineral processing (including cement and concrete products)
- paper and allied products
- petroleum refining
- wood products
- other industries (food and beverage, electrical and electronics equipment, transportation equipment, service industries)

Point Source Emissions Estimation Method

For each Lower Fraser Valley (LFV) permit, emissions were estimated by the Air Quality Department of the Greater Vancouver Regional District (GVRD) for the 1998 calendar year. In order of decreasing confidence, these estimates were based on continuous emission monitoring data, discrete stack sample data, material balance, emission factors, published correlations, or permit limits. The GVRD also estimated emissions for Ministry-authorized sources operating in the LFV outside the GVRD.

Area Sources

Area sources are all other stationary sources not regulated by a permit and therefore not included in point sources. They include a large number of small emission sources such as residential wood combustion. The following table describes the types of activities categorized.

Area Source Inventory categories for 1998:

Category	Description
agricultural	including emissions from farm animals, manure, the application of fertilizers and pesticides, farm equipment and sources of fugitive dust such as tilling and wind erosion of soil;
burning	including agricultural burning, forest fires, prescribed burning, incineration, open burning, landclearing and structural fires;
fuel marketing	the distribution of gasoline and other refined petroleum products, from the refinery to the end-user. The main emission sources are storage and transfer operations at tank farms, marketing terminals, marine terminals, bulk plants, service stations, fleet refueling stations, and cargo tankers;
landfills	municipal solid waste landfills as well as industrial landfills;
solvent evaporation	emissions from commercial/light industrial solvent use or the use of products that contain volatile solvents as a necessary part of their formulation. This sector includes consumer products; dry cleaning operations; glues, adhesives and sealants; metal degreasing and cleaning; architectural paints, stains and finishes; automotive refinish operations; other commercial/industrial surface coating; pesticide formulation; and printing inks;
space heating	the combustion of natural gas, fuel oil or wood to provide space or water heating in residential, commercial, or institutional applications;
miscellaneous area sources	including bakeries, construction and demolition, tobacco smoke, and meat cooking.

Source: 1998 Air Emissions Inventory for the Lower Fraser Valley Airshed

Area Sources Emissions Estimation Method

Estimation of area sources is based on population or other base quantities multiplied by an established emission factor.

Mobile Sources

The 1998 mobile source emission inventory categories:

- on-road motor vehicles
- aircraft
- railways
- marine vessels
- other off-road vehicles and engines such as lawn and garden, agricultural, construction, and general utility vehicles and equipment.

Mobile Sources Emissions Estimation Method

Methods for estimating mobile sources vary depending on the source. Motor vehicle emissions are estimated as the product of an emission rate, expressed as grams of contaminant emitted per vehicle-kilometre traveled, and a corresponding estimate of the distance traveled. Railway emissions are based on fuel consumption data and coal dust lost during transport.

Natural Sources

Natural sources are marine aerosol and wildfires. Only marine aerosols are listed in the Emissions Inventory for the Lower Fraser Valley Airshed 1998 report. Wildfires are reported as a natural emission source in the 1995 British Columbia Emissions Inventory report and in the Lower Fraser Valley in 1995 they contributed only .4% (37 tonnes).

Natural Sources Emissions Estimation Method

Marine aerosol emissions were estimated for 1995 using wind data. It was assumed that the marine aerosol emissions are unchanged from 1995 to 1998.

Road Dust Sources - not included in this Indicator

Preliminary **road dust** estimates have been determined for the LFV and the rest of the province. Large uncertainties exist in these estimates due to variations between locations and climatic considerations such as rain and snowfall. The Ministry of Water, Land and Air Protection and the GVRD are continuing to study road dust in order to improve confidence in future estimates. A comprehensive sampling study is currently being undertaken by the GVRD to better estimate road dust emissions in the Lower Fraser Valley (Ken Reid GVRD, Personal Communication 2000). Adding to the uncertainty over fugitive road dust emission estimates is that they are difficult to characterize, and the methodologies to quantify these emissions are undergoing refinement.

Supporting Information

Area of Crown land (in hectares) in the Georgia Basin where burning methods were used for site preparation, from 1981/82 to 1995/96.

Hectares prepared by burning in the Lower Mainland	
Year	Lower Mainland
81/82	1,868
82/83	3,335
83/84	7,506
84/85	6,970
85/86	3,809
86/87	5,997
87/88	6,168
88/89	3,978
89/90	2,243
90/91	1,818
91/92	3,313
92/93	2,361
93/94	2,244
94/95	1,936
95/96	933

Source: British Columbia Ministry of Forests Annual Reports, various years.

References:

Greater Vancouver Regional District, Air Quality Branch 1998. Emission Inventory for the Lower Fraser Valley Airshed. 1998.

Ministry of Environment Lands and Parks, Air Resources Branch. 1999. 1995 British Columbia Emissions Inventory of Common Air Contaminants and Greenhouse Gases.

Air Quality from PM₁₀ in the Puget Sound

Regulatory Framework

Air quality in Puget Sound is a shared responsibility between the Washington State Department of Ecology (<http://www.ecy.wa.gov>) and three local air agencies: the Northwest Air Pollution Authority (<http://www.nwair.org>), Puget Sound Clean Air Agency (<http://www.pscleanair.org>), and the Olympic Air Pollution Control Authority (<http://www.oapca.org>). The Federal Environmental Protection Agency, with a regional office in Seattle, (<http://www.epa.gov>) has primarily an oversight role regarding air quality in Puget Sound. Ecology and the local clean air agencies have delegated authority to control air quality through both federal and state law. Puget Sound air quality is controlled primarily through the Federal Clean Air Act (42 United States Code 7401 *et. seq.*) and the Washington Clean Air Act (Revised Code of Washington, or RCW 70.94) and the administrative regulations issued under those laws.).

At the federal level, EPA has issued ambient air quality standards for what are termed “criteria” air pollutants. The standards are referred to as NAAQS (National Ambient Air Quality Standards). EPA has established national standards for PM₁₀ at 50 ug/m³ for an annual arithmetic mean, and 150 ug/m³ for a 24-hour average. The standards for PM_{2.5} are 15 ug/m³ and 65 ug/m³ respectively. Washington State has incorporated these standards. NAAQS have also been established for lead, sulfur dioxide, carbon monoxide, ozone and nitrogen dioxide. Regulations are implemented through a variety of mechanisms including permits, inspections, technical assistance, outreach to smaller businesses and education to the general public.

The table below shows the different action levels at which PM₁₀ is regulated throughout the Puget Sound - Georgia Basin: Note: all values in the table are based on concentrations of PM₁₀ averaged over 24 hours.

PM ₁₀ : 00-25 ug/m ³	In BC, the range within which health impacts may be occurring, but statistical evidence points to health impacts at concentrations in excess of 25 ug/m ³
PM ₁₀ : 25-50 ug/m ³	BC air quality objective is 50 ug/m ³
PM ₁₀ : 50-75 ug/m ³	US upper limit for good air quality is 75 ug/m ³
PM ₁₀ : 75 – 149ug/m ³	US upper limit for moderate air quality is 149ug/m ³
PM ₁₀ : >150 ug/m ³	US standard for unhealthful air quality is 150 ug/m ³

Sampling Equipment and Methodology

To sample PM₁₀, the Department of Ecology uses a Sierra-Anderson or General Metal Works Model 1200 PM₁₀ High-Volume Air Sampler system consisting of a Sierra-Anderson or General Metal Works Model 1200 PM₁₀ Size-Selective Inlet, an anodized aluminum high volume shelter with stainless steel filter holder, a 0.6 hp motor, a pressure transducer flow recorder, a volumetric flow controller, a six day timer/programmer, an elapsed time indicator and a filter cartridge. This is considered a

Federal Reference Manual Method Instrument. Please refer to Ecology publication #95-201D *High Volume PM₁₀ Volumetric Flow Controlled Procedures* for further detail.

Ecology uses a rigorous quality assurance protocol in which a high-volume (HV) Volumetric Flow Control (VFC) sampler draws a known volume of ambient air at a constant flow rate through a size-selective inlet. Particles in the PM₁₀ size range are then collected on a filter during a specified 24-hour sampling period. Each sample filter is weighed before and after sampling to determine the net weight (mass) gain of the collected PM₁₀ sample. The reference method for PM₁₀ sampling is found in the Code of Federal Regulations, Title 40, Section 50, Appendix J.

Based on qualitative and quantitative review of the data, there should be at least 80% certified valid data from each monitoring instrument. Percent valid data is a gauge of the amount of certified valid data obtained from a monitoring instrument compared to the amount expected under ideal conditions (24 hours per day, 365 days per year). Completeness of the data is determined for each monitoring instrument, the sampling period and frequency taken into account and the results expressed as a percentage in Table 1, Air Quality Monitoring Data Quality Assessment Report. When the 80% certified data objective is not met, the result is highlighted and an explanation given. The manual method sampling frequency is noted after the station identification number, such that 1/1, 1/3 and 1/6 denotes every day, every third day, and every sixth day sampling frequency respectfully. Please refer to Ecology publications 1998 and 2000 *Air Quality Monitoring Data Quality Assessment Reports*.

Finding Solutions

The Department of Ecology and its partner air quality agencies are deeply committed to improving air quality and protecting public health and the environment. Among the ways in which PM₁₀ is addressed are:

1. Collaborative research with the University of Washington and other partners regarding health effects and correlative factors
http://depts.washington.edu/envhlth/info/research_pubs.html and
<http://www.ce.wsu.edu/>.

2. Vehicle emissions testing, including diesel powered fleets. Washington's Emissions Check Program applies to vehicles registered in areas that have experienced carbon monoxide or ground-level ozone problems attributable largely to motor vehicles. This includes urban areas of King, Pierce, Snohomish, Spokane and Clark counties. The Program reduces air pollution by identifying the most polluting vehicles and requiring their repair, resulting in the reduction of 146,400 tons of pollutants each year.

During 1999, over 93 billion vehicular miles were traveled in Puget Sound, although strides were made in promoting and implementing alternative transportation options such as van and carpools, light rail, ferry, bicycles, buses and walking. The Washington State Department of Transportation, the Puget Sound Regional Council and a stable of other partners are working on long-range transportation planning to dramatically reduce the number of single-occupancy vehicle miles traveled by working on Commute Trip Reduction by employers. In addition, Ecology outreach and education staff promotes transportation alternatives in their materials and program plans.

3. Outdoor Burn Bans, Permits and Outreach: Most outdoor burning has been banned in urban areas surrounding Puget Sound. Outdoor burning, where still allowed, is curtailed on high pollution days. Outdoor burning is still fairly prevalent in rural communities and has been addressed through permit programs, outreach, public education and proffering alternatives to burning, such as composting.

4. Wood Stove and Fireplace Certification: In 1995, EPA promulgated new emission standards that apply to both wood stoves and fireplaces, both of which are significant contributors to PM₁₀ pollution. Washington State adopted more stringent standards in 1991. These standards are set forth in the Washington Administrative Code, or WAC 173-433). The emission limit for both wood stoves and fireplaces is 4.5 grams/hour (non-catalytic) and 2.5 grams/hour (catalytic). Due to budgetary constraints, Ecology is no longer able to offer technical assistance, but the web site does contain a list of all retailers and dealers who sell certified products, as well as information on the public health ramifications of wood smoke. Please see <http://www.ecy.wa.gov/program/air/91-053.html#certified> stoves for further information.

5. Industrial Permitting: Ecology and the local air agencies issue permits to control air pollution emitted by different sources such as plywood mills, aluminum smelters, dry cleaners, incinerators and a range of other sources (see characterization of point sources below). Permits can include limits on emissions of specific pollutants, as well as requirements for monitoring, record keeping, and reporting compliance.

6. Agricultural Burning: Although large scale agricultural burning is confined primarily to the eastern region of Washington State, it has become a controversial public health and property rights issue that affects the entire region. The Department of Ecology has invested in research, held several forums to identify alternatives to large scale burning such as alternative product development, composting, landfilling and incineration. As a result of the introduction of alternatives and regulatory programs, since 1998 agricultural burning of grass seed and cereal grain fields has been reduced by over 40%.

Supporting Data Charts:

	PM 10 • Number of readings Collected					total yearly count
	0-24	25-49	50-74	75-99	>100	
1994	2643	1574	304	69	16	4606
1995	2949	1294	238	54	8	4543
1996	2620	1131	192	65	17	4025
1997	3411	1511	259	81	29	5291
1998	2545	982	146	39	9	3721
1999	1991	771	106	26	9	2903
	Percent of readings in each range					total percentage
	0-24	25-49	50-74	75-99	>100	
1994	57.382%	34.173%	6.600%	1.498%	0.347%	100%
1995	64.913%	28.483%	5.239%	1.189%	0.176%	100%
1996	65.093%	28.099%	4.770%	1.615%	0.422%	100%
1997	64.468%	28.558%	4.895%	1.531%	0.548%	100%
1998	68.396%	26.391%	3.924%	1.048%	0.242%	100%
1999	68.584%	26.559%	3.651%	0.896%	0.310%	100%

Calculation Of Percent Of Readings Collected That Fall Into The Set PM10 Ranges.1999	PM10 Annual Arithmetic Means (µg/m³)			
	1st High		2nd High	
Station	Date	Conc.	Date	Conc.
530770012	1/6	123.00	1/9	77.00
530770011	1/6	134.00	10/21	82.00
530770005	8/4	88.00	10/21	76.00
530730015	10/21	31.00	6/11	26.00
530730007	1/1	24.00	1/6	18.00
530711001	6/23	297.00	7/11	91.00
530710005	1/24	87.00	8/25	71.00
530670013	11/2	38.00	10/21	35.00
530650004	1/30	205.00	2/14	60.00
530632002	3/19	61.00	10/21	60.00
530631017	7/7	72.00	9/15	55.00
530630047	9/21	54.00	10/21	54.00
530630016	9/25	343.00	9/23	128.00
530630001	10/21	43.00	9/21	40.00
530611007	10/21	42.00	9/21	35.00
530610018	3/7	27.00	1/24	25.00
530531018	2/11	53.00	10/21	43.00
530531004	10/21	52.00	7/5	40.00
530530031	9/21	72.00	9/22	61.00
530530021	6/11	50.00	9/3	42.00
530370002	1/3	48.00	10/21	46.00
530351005	11/2	34.00	1/24	33.00
530332004	10/21	51.00	12/29	51.00
530330086	1/24	33.00	3/7	21.00
530330057	5/6	53.00	10/20	53.00
530330024	12/26	34.00	10/21	31.00
530330022	4/24	20.00	3/19	19.00
530330021	5/6	29.00	3/19	28.00
530330020	3/7	21.00	5/24	19.00
530330004	9/15	25.00	4/18	22.00
530150006	10/21	45.00	9/21	38.00
530110013	12/26	37.00	1/24	32.00
530070006	2/2	47.00	9/21	44.00
530050002	9/25	306.00	9/23	184.00
530030004	10/21	89.00	7/29	82.00

Average Annual Arithmetic Means of PM₁₀ for Puget Sound Sample Stations, 1999

1999	PM10 Annual Arithmetic Means ($\mu\text{g}/\text{m}^3$)			
	1st High		2nd High	
Station	Date	Conc.	Date	Conc.
530770012	1/6	123.00	1/9	77.00
530770011	1/6	134.00	10/21	82.00
530770005	8/4	88.00	10/21	76.00
530730015	10/21	31.00	6/11	26.00
530730007	1/1	24.00	1/6	18.00
530711001	6/23	297.00	7/11	91.00
530710005	1/24	87.00	8/25	71.00
530670013	11/2	38.00	10/21	35.00
530650004	1/30	205.00	2/14	60.00
530632002	3/19	61.00	10/21	60.00
530631017	7/7	72.00	9/15	55.00
530630047	9/21	54.00	10/21	54.00
530630016	9/25	343.00	9/23	128.00
530630001	10/21	43.00	9/21	40.00
530611007	10/21	42.00	9/21	35.00
530610018	3/7	27.00	1/24	25.00
530531018	2/11	53.00	10/21	43.00
530531004	10/21	52.00	7/5	40.00
530530031	9/21	72.00	9/22	61.00
530530021	6/11	50.00	9/3	42.00
530370002	1/3	48.00	10/21	46.00
530351005	11/2	34.00	1/24	33.00
530332004	10/21	51.00	12/29	51.00
530330086	1/24	33.00	3/7	21.00
530330057	5/6	53.00	10/20	53.00
530330024	12/26	34.00	10/21	31.00
530330022	4/24	20.00	3/19	19.00
530330021	5/6	29.00	3/19	28.00
530330020	3/7	21.00	5/24	19.00
530330004	9/15	25.00	4/18	22.00
530150006	10/21	45.00	9/21	38.00
530110013	12/26	37.00	1/24	32.00
530070006	2/2	47.00	9/21	44.00
530050002	9/25	306.00	9/23	184.00
530030004	10/21	89.00	7/29	82.00

Average Annual Arithmetic Means of PM₁₀ for Puget Sound Sample Stations, 1999

HPMS Miles and VMT by County. Information is from the 1999 HPMS database.

County Name	County Number	Local		Total		DVMT	AVMT in 1000s
		Centerline Miles	Lane Miles	Centerline Miles	Lane Miles		
Adams	1	1,669.84	3,339.68	2,604.08	5,380.80	1,389,635	507,217
Asotin	3	368.60	737.20	589.50	1,186.95	267,114	97,497
Benton	5	1,299.47	2,598.94	1,981.66	4,219.58	3,460,218	1,262,980
Chelan	7	1,873.48	3,746.96	2,317.07	4,741.39	1,722,151	628,585
Clallam	9	710.85	1,421.70	1,063.27	2,165.05	1,269,615	463,409
Clark	11	1,894.48	3,788.96	2,642.12	5,610.75	6,874,647	2,509,246
Columbia	13	567.25	1,134.50	844.19	1,693.28	202,437	73,890
Cowlitz	15	691.22	1,382.44	1,158.56	2,622.36	3,132,122	1,143,225
Douglas	17	2,475.92	4,951.84	3,138.68	6,303.37	1,046,687	382,041
Ferry	19	1,406.00	2,812.00	1,794.58	3,589.16	320,780	117,085
Franklin	21	1,204.63	2,409.26	1,752.29	3,670.26	1,538,798	561,661
Garfield	23	326.60	653.20	586.40	1,181.46	178,317	65,086
Grant	25	2,409.13	4,818.26	3,758.46	7,693.33	2,399,088	875,667
Grays Harbor	27	1,067.26	2,134.52	1,582.09	3,249.45	1,778,293	649,077
Island	29	1,077.95	2,155.90	1,365.34	2,757.56	1,070,797	390,841
Jefferson	31	653.81	1,307.62	938.89	1,882.14	849,726	310,150
King	33	5,293.74	10,587.48	7,425.46	16,550.17	43,956,669	16,044,184
Kitsap	35	1,177.64	2,355.28	1,683.46	3,547.41	4,230,576	1,544,160
Kittitas	37	1,940.24	3,880.48	2,471.03	5,231.51	2,554,972	932,565
Klickitat	39	928.41	1,856.82	1,491.74	3,009.91	663,752	242,269
Lewis	41	1,209.54	2,419.08	1,788.60	3,696.82	2,756,262	1,006,036
Lincoln	43	1,608.45	3,216.90	2,531.15	5,094.66	873,418	318,798
Mason	45	563.58	1,127.16	975.37	1,972.82	1,147,151	418,710
Okanogan	47	2,799.58	5,599.16	3,611.48	7,235.58	1,275,236	465,461
Pacific	49	435.11	870.22	738.53	1,495.23	617,152	225,260
Pend Oreille	51	1,242.41	2,484.82	1,527.94	3,068.45	414,647	151,346
Pierce	53	2,485.74	4,971.48	3,869.57	8,549.54	15,287,139	5,579,806
San Juan	55	262.39	524.78	350.39	700.78	90,456	33,016
Skagit	57	837.79	1,675.58	1,485.79	3,101.86	3,189,996	1,164,349
Skamania	59	788.92	1,577.84	913.35	1,830.25	254,939	93,053
Snohomish	61	2,768.47	5,536.94	3,813.19	8,125.74	13,881,015	5,066,570
Spokane	63	3,228.74	6,457.48	4,634.87	9,891.74	8,805,471	3,213,997
Stevens	65	1,462.45	2,924.90	2,292.77	4,600.83	1,059,464	386,704
Thurston	67	1,016.58	2,033.16	1,586.15	3,407.27	5,226,533	1,907,685
Wahkiakum	69	64.95	129.90	191.03	393.21	125,837	45,931
Walla Walla	71	638.32	1,276.64	1,295.39	2,674.36	1,149,336	419,508
Whatcom	73	1,173.45	2,346.90	1,850.62	3,826.10	3,609,964	1,317,637
Whitman	75	1,487.80	2,975.60	2,423.25	4,874.87	1,143,893	417,521
Yakima	77	1,968.15	3,936.30	3,187.92	6,687.80	4,602,695	1,679,984
Total		55,078.94	110,157.88	80,256.25	167,513.80	144,417,000	52,712,207
A multiplication factor was applied to the DVMT's and AVMT'S to adjust the county totals for "local" traffic. Local roads are assumed to have two lanes.							